PATENT SPECIFICATION

DRAWINGS ATTACHED

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Int. Cl.: —**G 06 k 1/12//G 02 b**

COMPLETE SPECIFICATION

Information Recording and Retrieval

We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America, of 343, State Street, Rochester, New York 14650 United States of America (Assignees of ROBERT LEWIS LAMBERTS and GEORGE CLINTON HIGGINS) do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to information storage and retrieval, and more particularly to an apparatus and method for converting a combination of electrical signals representative of an item of information into a grating pattern on an optical material, and to an apparatus and method for decoding such a pattern.

In many modern applications of information storage and retrieval, an item of information is represented by a combination of a group of binary "bits". Since most physical devices have two distinct states, for example, punched tape or card (hole or no hole), magnetic tape (magnetized or nonmagnetized area), relays (open or closed), photographic film (exposed or unexposed area), etc., these binary states can be used to indicate the presence or absence of one or more bits, thereby designating different combinations of such binary conditions.

It is generally recognized that the theoretical amount of information that can be stored within a given area of photographic film is greater than for many other types of mediums because of the very high resolution available in photosensitive emuslions. However, in any system using photographic film for the storage of information, the amount of information that can be stored per unit area, commonly termed information packing or density, is many orders of magnitude below the theoretical limit. This limitation has arisen from the problem of locating a small area, either mechanically or optically, and because of the possibility of spurious signals being introduced due to dust, dirt and scratches on the film.

In the conventional photographic data recording systems, accuracy is achieved by making the code area comparatively large and this, in effect, introduces redundancy in that a large area can be considered as a number of small areas placed side by side, Additionaly, when large code areas are used, the full resolution capabilities of the film are not utilized. In most photographic data recording systems, use is made of no more than a few lines per millimeter resolution, although certain films are capable of resolving over 1,000 lines per millimeter.

An important object of the invention is to provide an apparatus and method of recording items of information on a photographic film which permits more information to be recorded per unit area and a greater use to be made of the resolving power of the film.

As is well known to those skilled in the art, when parallel monochromatic light passes through a diffraction grating and is focused by a lens onto a screen, a central bright image is formed together with bands of light (successive "spectral orders") on either side of it separated by dark spaces. The smaller the grating interval (the more lines per unit length), the more divergent and sharply defined are the spectral orders, but the spectral lines formed by one uniform grating are exactly similar to those formed by another, except as to divergence. It follows that, with a monochromatic light source, the angle of the diverging beam from the grating for each spectral order increases as the grating interval decreases. Therefore, the first order spec-

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tral lines for different grating intervals occupy different positions from which their respective grating intervals can be determined for any frequency of source light.

In the present invention, use of the high resolution of photographic film for information recording and retrieval is made by forming an image which can be differentiated from a piece of dirt or a scratch on the film. This is accomplished by exposing the film to a composite pattern which comprises a plurality of uniform gratings with different intervals, each representing the presence of a respective "bit" of the item of information. When the developed image of such a composite pattern is illuminated with monochromatic light, each of the first order spectra that are formed corresponds to a respective one of the uniform grating patterns. Since the composite pattern comprises the sum of the uniform gratings having different grating intervals, the presence or absence of a given first order spectrum can be used to represent the presence or absence of a corresponding binary bit.

The invention will be described further, by way of examples, with reference to the accompanying drawings wherein like reference numerals designate like parts and wherein:

Fig. 1 is a schematic perspective view of an optical system in which a photographic line grating is used as a diffraction grating;

Fig. 2 is a schematic perspective view of an optical system in which a photographic line grating having spatially varying opacity is used as a composite diffraction grating;

Figs. 3—5 are representations of a single zero order spectral line and a group of first order spectral lines showing the relation of the first order spectral lines derived from photographic line gratings having different grating intervals;

Fig. 6 is a representation of an item of information encoded on film by means of bits and by means of a composite pattern comprising a plurality of grating patterns, each having its own discrete periodic structure;

Figs. 7—9 are perspective views of different systems for recording an item of information on film as a composite pattern comprising a plurality of grating patterns;

Fig. 10 is a representation of a diffraction pattern that is obtained from an oriented composite pattern illuminated with a monochromatic point source;

Fig. 11 is a perspective view of an optical system for decoding a composite pattern having spatially varying opacity and recorded on a strip of photographic film;

Fig. 12 is a perspective view of a coherently illuminated optical system for producing a composite pattern having spatially varying opacity; and

Fig. 13 is a perspective view of another embodiment of the coherently illuminated optical system shown in Fig. 11.

With particular reference to Fig. 1, a photographic line grating 10 can be used as a diffraction grating to provide a zero order spectral line and a first order spectral line. This is accomplished when a monochromatic light source 11 is used to illuminate a slit 12 in a mask or plate 13, the slit being imaged by means of a lens 14 coincident with the zero order line. The photographic grating 10 is placed at the lens aperture so that first and higher order spectral lines are formed alongside the slit image. By placing a photocell 15 in the position of either of the respective first order lines, it can be determined whether or not there is a particular grating pattern in the lens aperture. It can be readily appreciated that the problem of dirt or dust on the grating 10 or of scratches in the grating is very much reduced.

A similar system is disclosed in Fig. 2 in which a composite photographic pattern 20 comprises a plurality of grating patterns, each having a unique, uniform grating interval. When the composite pattern 20 is positioned in the lens aperture, a number of first order spectral lines appear which correspond to the number of uniform grating patterns forming the composite pattern. As shown in Fig. 1, a group of photocells 21 can be arranged in the equivalent positions of the first order spectral lines to convert the number of spectral lines formed by pattern 20 into a corresponding number of electrical signals. According to grating theory, the distance from the zero order spectral line, that is, the direct image, to any one of the first order spectral lines is inversely proportional to the grating interval of its respective grating pattern.

In most instances where a binary-six code is used for representation of an item of information, an additional bit is usually recorded with each combination of digital bits as a timing mark. As a result, for this particular code arrangement a maximum of seven bits or a minimum of two bits can be recorded as representative of a particular item of information. If the ratio of the maximum to the minimum grating interval is less than two, the possibility of second order spectral lines falling in the same position as the first order spectral lines is eliminated. The second order spectral lines can also be eliminated by choosing a group of grating intervals such that the second order spectral lines transmitted thereby lie between the first order spectral lines of other grating intervals in the same group. However, the second order spectral lines are usually not of sufficient brightness to trigger a photocell so as to produce a spurious signal. The first order spectral lines are, therefore, indicative of the grating intervals that have actually been used to form the composite pattern.

In Figs. 3—5, as an exampe, grating intervals for producing 70, 80, 90, 100, 110, 120

and 130 cycles per millimeter are used, all of which are within an octave. Where the composite pattern comprises seven grating intervals to produce the above, assuming a binary-six code with a timing mark, seven first order spectral lines are formed, as shown in Fig. 3. In Fig. 4, the grating interval for producing the 120 cycle per millimeter line has not been recorded and similarly, in Fig. 5, the grating interval for producing the 90 cycle per millimeter line has not been recorded. Accordingly, any combination of the first order spectral lines can be obtained and are spaced in accordance with the combination of the grating intervals used to form the composite pattern.

In Fig. 6, the upper portion thereof shows the size and placement of the clear and opaque code bits as used for packing about 10^6 bits per sq. in. Since the size of an individual bit is 10μ high and 30μ wide, in order to obtain an accurate read out, any variation in film movement must be held to within a few microns. The lower portion of Fig. 6 shows the corresponding composite grating that provides equivalent information packing. It is apparent from the latter that the requirement for accurately guiding the film is much less for the composite pattern and likewise, dirt or a scratch would have a smaller effect upon the composite grating.

With reference to Fig. 7, a system is disclosed herein for recording information by means of a composite pattern. A tape 25, which is perforated with a combination of apertures 26 arranged transversely thereof and representative of an item of information, is moved past a light source 27 and a group of photocells 28. Each of the apertures 26 in a transverse group will transmit light to a corresponding photocell 28 which, in turn, will gate its corresponding oscillator circuit 29 to which the photocell is connected. Each of oscillators 29 provides a series of output signals of a different predetermined frequency. The group of frequencies provided by oscillators 29 can be chosen without regard to second order spectral lines or can be chosen to be within an octave so as to eliminate second order lines as described above. The oscillators are connected to a cathode ray tube 30 and the intensity of its beam is modulated by the frequency signals derived from the oscillators.

As is well known, information can be presented on the screen of a cathode ray tube by varying the density of the electron beam, which produces a change in the intensity of the spot of light on the face of the tube. If the intensity is made to change in accordance with some intelligence, the result is intensity modulation. Such modulation can be used to produce a series of equally spaced bright spots on the face of the tube which are indicative of equal periods of time. This can be accomplished by applying a cyclically repetitive signal to the cathode ray tube in such a way that the intensity of the trace is increased at regular intervals.

Since the oscillators 29 provide a combination of different frequencies in accordance with those that have been gated, the trace on the face of the tube 30 is a series of dark and bright spots representative of the sum of the frequencies produced by the gated oscillators. A cylindrical lens 31 is optically aligned with the trace on the face of tube 30 for converting the series of spots to a pattern of lines which, in effect, is a composite grating pattern that is imaged by a lens 32 on a photosensitive medium, such as film strip 33. Depending on the size of the film used and the size of the image pattern, the film strip 33 can be moved continuously or intermittenty in a longitudinal direction in accordance with the size of the pattern, or an optical system can be used which will display a number of such line patterns successively across the film in conjunction with the longitudinal movement of the film. In addition to the system just described, the film strip 33 can be positioned within the cathode ray tube 30 and exposed directly by the electron beam.

When the film is developed, the resulting image is a composite pattern of spatially varying opacity comprising a plurality of grating patterns, each pattern having a unique, uniform grating interval in accordance with the frequency of its respective oscillator. Such a composite grating pattern is illustrated in the lower position of Fig. 6. It should be obvious to those skilled in the art that oscillators 29 can also be gated by signals derived from information encoded on a magnetic tape, photographic film, punched cards, etc., or by signals derived from a computer or any other signal producing means. If the item of information on the medium from which the signals are derived for gating the oscillators is not compatible with the oscillator frequencies, a matrix circuit can be used to convert such signals to a combination usable by the oscillators.

While all the individual patterns in the composite pattern described above are oriented in the same direction, it is also possible to orient the individual patterns (θ modulation) so that the first order spectral lines lie in corresponding orientations. With this system, each angular orientation provides a linear position from which the presence or absence of a first order spectral line can be determined so that the oriented composite pattern would not have to be illuminated with monochromatic light. If, as in the above example, seven bits are required for representation of an item of information, then seven angular orientations of the film strip 33 are required. This same principle can be used for composite patterns in order to obtain a greater degree

of information packing. In order to produce an oriented composite pattern, the film strip 33 can be rotated through a predetermined angle after exposure to each composite pattern appearing on the face of tube 30, thereby obtaining a number of radially extending composite patterns that are superimposed on each other at the axis of rotation of the film strip. A diffraction pattern as shown in Fig. 10 can be obtained when an oriented composite pattern consisting of four composite patterns, each of which is oriented at a different angle, is illuminated by a point source of illumination, such as a mercury-vapour lamp.

In Figs. 8 and 9, an optical plate 40 which comprises an array of areas having variable transmittance characteristics is imaged by a lens 41 on a film strip 42. The plate 40 comprises an array of a number of gratings 43 having different grating intervals, or a number of members having different sinusoidal cross sections. In either case, each grating or member has a predetermined transmission characteristic such that, when illuminated, it transmits a line pattern of light in which the lines are uniformly spaced. In this arrangement, each grating 43 is illuminated by an individual flash lamp 44 and condenser system 45, only three of which are shown, the lamps 44 being energized by a corresponding photocell which can be arranged in the same manner as shown in Fig. 7 for deriving a signal from each code bit in a punch tape or other medium, or the lamps can be energized by a group of signals transmitted directly thereto from a signal producing means as set forth above. The light passing through any one of gratings 43 emerges as a line pattern of light, the lines being uniformly spaced in accordance with its respective grating. This pattern is imaged and reduced in size by lens 41. Each such pattern can be superimposed on one another by taking advantage of the film movement, whereby the top pattern is exposed first and subsequent exposures are delayed until the film is moved to a position in which the next pattern is imaged. When the latent image on the film is developed, a composite pattern is obtained, which is a plurality of superimposed grating patterns, and has spatially varying opacity. The grating patterns are derived from those of gratings 43 that are actually illuminated.

Instead of accomplishing superposition by use of the film motion, a cylindrical lens 47 and a mask having a slit or aperture 48 can be arranged in the optical system, as shown in Fig. 9. This modification allows all of the patterns formed by any combination of the gratings 43 to be exposed simultaneously. In the azimuth in which the cylindrical lens 47 has no effect, that is, the horizontal azimuth, the test objects 43 are formed on the film 42 by objective lens 41. In the other azimuth, that is, the vertical azimuth, the images of each of the test objects 43 are spread and are all superimposed. For optical efficiency and uniformity, lenses 47 and 41 image the slit 48 onto the film in the vertical azimuth and lens 47 images the test objects 43 into the aperture of lens 41 in the same azimuth. Since the gratings 43 are not in sharp focus in a vertical direction, it is possible with this system to use either type of grating, that is, one of variable transmittance or one of variable area. The same result can be attained by light that is reflected from gratings 43 as well as light transmitted through the gratings.

A system for determining the presence of the first order spectral lines is shown in Fig. 11. Basically, the presence or absence of first order spectral lines derived from a composite pattern can be determined by placing photocells in the positions of the first order spectral lines as described above and shown in Figs. 1 and 2. However, for small code areas, it is necessary to provide a system for illuminating only one of the composite patterns on the film at a time. Such a system comprises a slit 50 in a mask or plate 51 which is illuminated by a high-pressure mercury lamp 52, the arc being projected onto the slit 50 by a lens 53. The slit is then imaged by a lens 54 to form a real image 55 in space and this image is then projected by a lens 56 onto a group of photocells 57 that are positioned behind a film strip 58 and in the focal plane of lens 56. The lens 56 also images a slit 59 in a mask or plate 60 onto the film so that the area actually illuminated is a reduced image of the slit 59 and corresponds to the area on the film that is to be decoded. Since the real image 55 cooperates with slit 59 to provide a small source of illumination in the conjugate focal plane of lens 56, a coherent system of illumination for the grating on film 58 is effectively formed, as described hereinbelow. A cylindrical lens, not shown, can be placed behind the film to concentrate the light along the length of the first order lines thereby collecting it more effectively onto the photocells

For imaging a composite pattern, there is considerable gain to be achieved in definition and in depth of field tolerances by using coherent illumination rather than the more commonly used incoherent illumination. A simple coherently illuminated optical system is shown in Fig. 12 for producing a composite pattern of a particular combination of grating intervals from a composite pattern comprising the full combination of the same grating intervals. A slit 65 in a mask 66 is illuminated by a point source 67 and the illuminated slit is imaged by a lens 68 in the aperture of an objective lens 69. When a composite pattern 70, comprising the sum of a plurality of grating patterns of seven different grating intervals, is placed directly behind the lens 68, a line spectrum 71 is formed in the aperture of the ob-

jective 69 comprising a single zero order spectral line and a group of seven first order spectral lines, as shown in Fig. 12. It can be shown theoretically that when these spectral lines are entirely within the lens aperture, there is no loss in the quality of an image 72 formed by the objective 69, provided the objective is substantially free from aberration. The image 72 that is formed by objective 69 is a reduced replica of the composite pattern 70 which can be imaged on a photosensitive medium. It has been found that acceptable images can be obtained by such a system over a depth of focus of at least .002 in., a depth which definitely exceeds that of a conventional system having the definition required for this type of recording. Since blocking any pair of first order spectral lines in the line spectrum 71 removes the corresponding line pattern from the image 72, any combination of grating intervals can be obtained by appropriately shuttering the first order spectral lines imaged in the objective aperture by means of a shutter responsive to a combination of electrical signals, each which corresponds to one of the first order spectral lines. It is essential, however, that any shutter that is used must be of such a structure that it does not distort the light waves passing through it.

In the system just described as well as that described above with respect to Fig. 7, the pattern presented by either type of grating 43 or the cathode ray tube 30 produces a diffraction grating pattern on the photosensitive medium or film which is of spatially varying opacity. However, the same systems can also be used to provide a phase grating pattern on a film which is of variable thickness and, when illuminated, produces a corresponding number of first order spectral lines.

In Fig. 13, a coherent optical system is shown which is a variation of the above-described system shown in Fig. 12 in that a series of individual gratings 75, such as described above with respect to Figs. 8 and 9 is used, and each of the individual gratings is coherently illuminated. A cylindrical lens 76 is positioned in front of a slit 77 in as mask 78 in such a way that a lens 79 images the slit 77 in one dimension onto the gratings 75, the slit 77 being illuminated by a point source 80. The remaining part of the system can be the same as that shown in Fig. 8 which includes a lens 81 for imaging the gratings 75 on a film strip 82, or can be modified with a second cylindrical lens, as shown in Fig. 9. Since the slit 77 is imaged on the gratings 75, only a portion of the slit illuminates each grating. A series of shutters, not shown, can be placed along the slit 77 to control illumination of any combination of the gratings 75. Because a narrow slit is used, a movement of only a few thousandths of an inch would be required to obscure any one of the gratings 75 so that this shuttering can be done mechanically.

It has been found that an item of information can be stored as a composite pattern comprising the sum of a plurality of grating patterns that are exposed onto a high quality film, each pattern having a unique, uniform grating interval and being individual to one of the bits in the combination representative of the item of information. To read the item of information so recorded on a photographic film, the composite pattern is used as a diffraction grating to form a number of first order spectral lines which correspond to a particular combination of bits representative of the item of information recorded. This system has the advantage that the image corresponding to an item of information is unique and can be distinguished from a piece of dirt or a scratch on the film. Furthermore, since the grating patterns are superimposed, the area occupied by a single item of information is larger than for conventional recording of a single bit. As a result, the problem of locating an area on the film is very much simplified by the system described hereinabove. In certain applications, advantage can be taken of coherent illumination and copies of such a composite pattern can be made by this means with very little loss in image quality.

While the invention has been described with respect to certain embodiments for both recording and measuring the information recorded as a grating, it is to be understood that various changes in the disclosed systems can be made by those skilled in the art without departing from the spirit of the invention. The invention, therefor, is not to be limited to the embodiments disclosed and described herein, but is of a scope as defined by the appended claims.

WHAT WE CLAIM IS:—

1. An information record comprising a discrete composite optical grating comprising a plurality of superimposed grating patterns, each having a unique, uniform grating interval and each, representing a respective bit of an item of information.

2. A record according to claim 1 wherein the ratio of the maximum to the minimum grating interval is less than two.

3. A record according to claim 1 or 2 wherein each grating pattern has more than 20 lines per millimeter and differs from the other grating patterns by at least 2 lines per millimeter.

4. A record as claimed in claim 1, 2 or 3, wherein the plurality of grating patterns collectively represent said item of information.

5. A record as claimed in claim 1, 2, 3 or 4 wherein each grating comprises spatially varying transmission characteristics.

6. A record as claimed in any of claims 1

to 5 comprising a photosensitive medium having a developed image of a composite pattern of spatially varying opacity to provide the plurality of grating patterns each grating pattern extending over the whole area of the composite grating.

7. Apparatus for recording a plurality of discrete numerical digits, representing an item of information, as a composite pattern, comprising light means, respectively modulated by means associated with each of the digits and means for directing the modulated light, as a composite pattern comprising a plurality of individual grating patterns, each corresponding to a respective one of the numerical digits, onto a photosensitive medium, each individual grating pattern having a unique, uniform grating interval.

8. Apparatus as claimed in claim 7 comprising means for translating each of the digits into an electrical potential and wherein the light means includes means responsive to each of said potentials to generate a respective output signal having a unique frequency, the light means being responsive to said group of output signals for displaying the latter as a composite pattern of individual grating patterns of spatially varying brightness.

9. Apparatus in accordance with claim 8, wherein said generating means comprises a plurality of oscillators.

10. Apparatus in accordance with claim 8 or 9 wherein said light means comprises a cathode ray tube whose sweep is modulated by said output signals to generate a composite pattern representing the combined frequencies of said output signals, and the directing means comprises an optical system to form an image of said composite grating on said photosensitive medium.

11. Apparatus in accordance with claim 10 wherein the optical system comprises a cylindrical lens optically aligned with the composite pattern.

12. An apparatus for recording an item of information which is encoded as a pattern of indicia on a medium, comprising in combination, means cooperating with said medium for generating a plurality of signals representing said pattern of indicia, means responsive to each of said signals for generating a respective control signal having a unique frequency, means responsive to said control signals collectively for displaying the latter as a composite pattern comprising a sum of individual grating patterns of spatially varying brightness, each individual grating pattern having a unique, uniform grating interval and corresponding to one of said frequencies, a photosensitive medium, and means for forming an image of said composite grating on said photosensitive medium.

13. An apparatus in accordance with claim 12 wherein said displaying means comprises a cathode ray tube whose sweep is modulated by said control signals to generate a composite pattern representing the combined frequencies of said control signals, and a cylindrical lens optically aligned with said composite pattern for forming an image of the latter as a composite grating.

14. An apparatus for recording an item of information which is encoded as a pattern of indicia on a medium, comprising in combination, means cooperating with said medium for generating a plurality of signals representing said pattern of indicia, means including a plurality of variable transmittance elements adapted to be selectively illuminated for generating a plurality of grating patterns equal in number to said signals, each grating pattern having a unique, uniform grating interval corresponding to one of said signals, means responsive to each of said signals for generating a respective control signal for controlling illumination of a corresponding one of said elements, and means for imaging said grating patterns on a photosensitive medium.

15. An apparatus in accordance with claim 14 wherein said imaging means comprises means defining an aperture, a cylindrical lens and an objective lens for imaging a composite pattern of the illuminated elements.

16. Apparatus, for reading an item of information recorded on a photosensitive medium as a composite pattern which comprises a sum of individual uniform grating patterns of spatially varying transmission characteristics and corresponding to a pattern of indicia representing said item of information, comprising, in combination, means for illuminating said photosensitive medium, an optical system including means defining an aperture, said optical system being arranged between said illuminating means and one side of said photosensitive medium for imaging said aperture on the latter and relative to said composite pattern whereby a group of first order spectral lines corresponding to said pattern of indicia is formed on the other side of said photosensitive medium, and means arranged on the other side of said photosensitive medium for photoelectrically converting said first order spectral lines into an equal number of discrete signals.

17. Apparatus in accordance with claim 16 wherein said optical system comprises a first means defining a first slit, a first lens system for projecting said illuminating means onto said first slit, a second means defining a second slit perpendicular to said first slit, a second lens system arranged between said first and second means for forming a real image of said first slit which cooperates with said second slit to coherently illuminate said photosensitive medium, and a third lens system for projecting said real image onto said converting means and said second slit onto the photosensitive medium in registry with said composite pattern.

18. Apparatus in accordance with claim 16 or 17 and including a cylindrical lens system arranged between said photosensitive medium and said converting means for concentrating said coherent illumination transversely of said first order of spectral lines.

19. A method of storing an item of information represented by a combination of a plurality of signals, which method comprises generating, from said combination of signals, a composite pattern comprising a plurality of superimposed gratings, each grating having a unique uniform grating interval and corresponding to one of said signals, and recording said composite pattern on a storage medium.

20. A method as claimed in claim 19 wherein each grating has a grating interval whose reciprocal differs from that of any other grating by no more than a factor of two.

21. A method as claimed in claim 19 or 20 wherein the composite pattern is recorded by exposing a photosensitive medium to said pattern.

22. A method as claimed in claim 19, 20 or 21 wherein the signals are applied successively and a different one of the plurality of gratings is produced in accordance with each of said signals to generate a succession of grating patterns and superimposing each of said grating patterns on a photosensitive medium for producing a composite grating.

23. A method of displaying an item of information recorded on a medium as a composite pattern comprising the sum of a plurality of superimposed individual grating patterns of spatially varying transmission characteristics which method comprises illuminating said composite pattern with monochromatic light, and so as simultaneously to image the corresponding plurality of first order spectral lines derived from said pattern on the medium.

24. A method of decoding an item of information recorded on a medium as a composite pattern comprising the sum of a plurality of superimposed individual grating patterns of spatially varying transmission characteristics which comprises illuminating said composite pattern with light, imaging simultaneously the corresponding plurality of first order spectral lines derived from said composite pattern, and determining said item of information from said first order spectral lines.

25. A method of decoding an item of information in the form of a composite pattern comprising a plurality of superimposed gratings, each grating having a unique, uniform grating interval which comprises illuminating said composite pattern with light whereby the first order spectra from the composite pattern consists of angular diverging beams each corresponding to one of said gratings, and photoelectrically converting said beams to a group of electrical signals unique to said item of information.

26. An information record substantialy as hereinbefore described with reference to and as illustrated in Fig. 6 or Fig. 10 of the accompanying drawings.

27. A method of recording an item of information, as claimed in Claim 19 and substantially as hereinbefore described.

28. A method of decoding a stored item of information as claimed in Claim 24 and substantially as hereinbefore described.

29. Apparatus for recording an item of information substantially as hereinbefore described with reference to and as illustrated in Fig. 7, 8, 9, 12 or 13 of the accompanying drawings.

30. Apparatus for decoding a stored item of information substantially as herenbifer described with reference to and as illustrated in Fig. 11, 12 or 13 of the accompanying drawings.

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Patent Agent.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1.

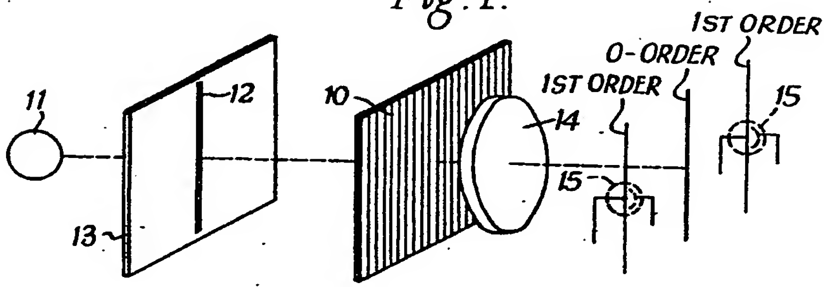


Fig. 2.

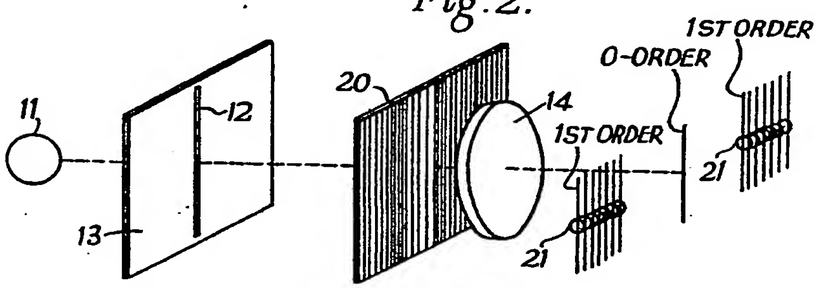
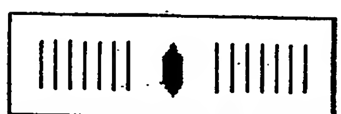
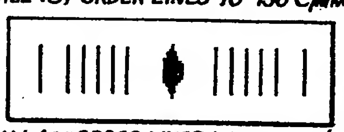


Fig. 3.



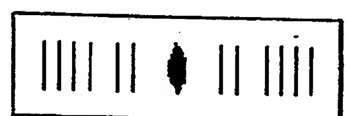
ALL 1ST ORDER LINES 70-130 C/MM



ALL 1ST ORDER LINES LESS 120 C/MM

Fig. 4.

Fig. 5.



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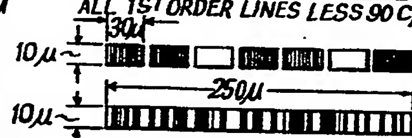

Fig. 6.

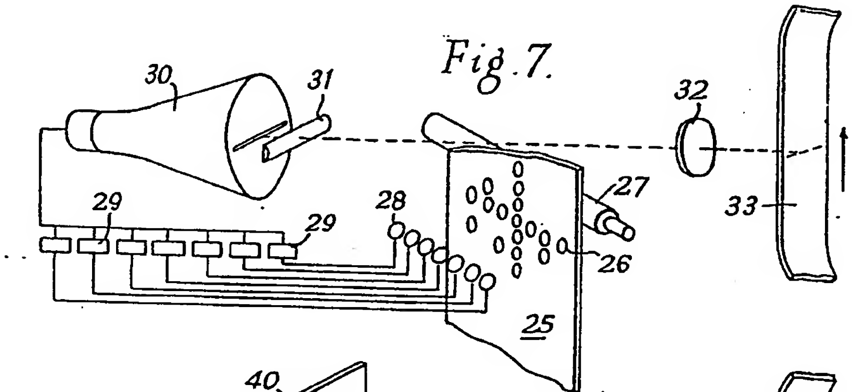

Fig. 7.

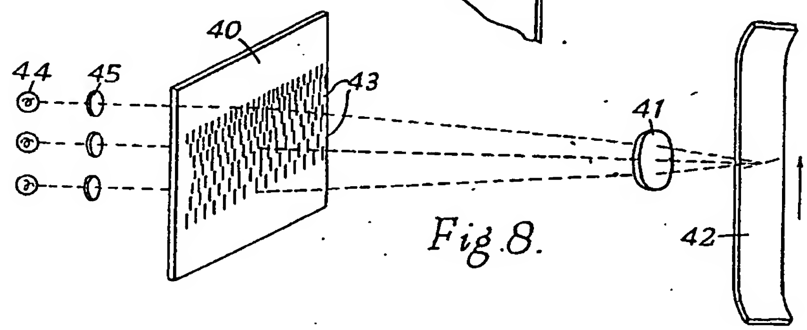

Fig. 8.

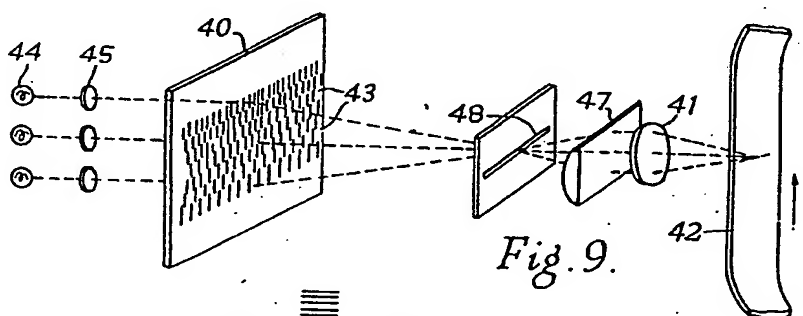

Fig. 9.

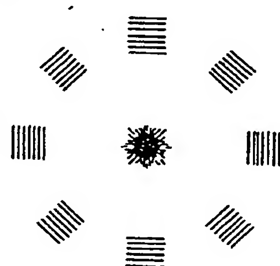

Fig. 10.

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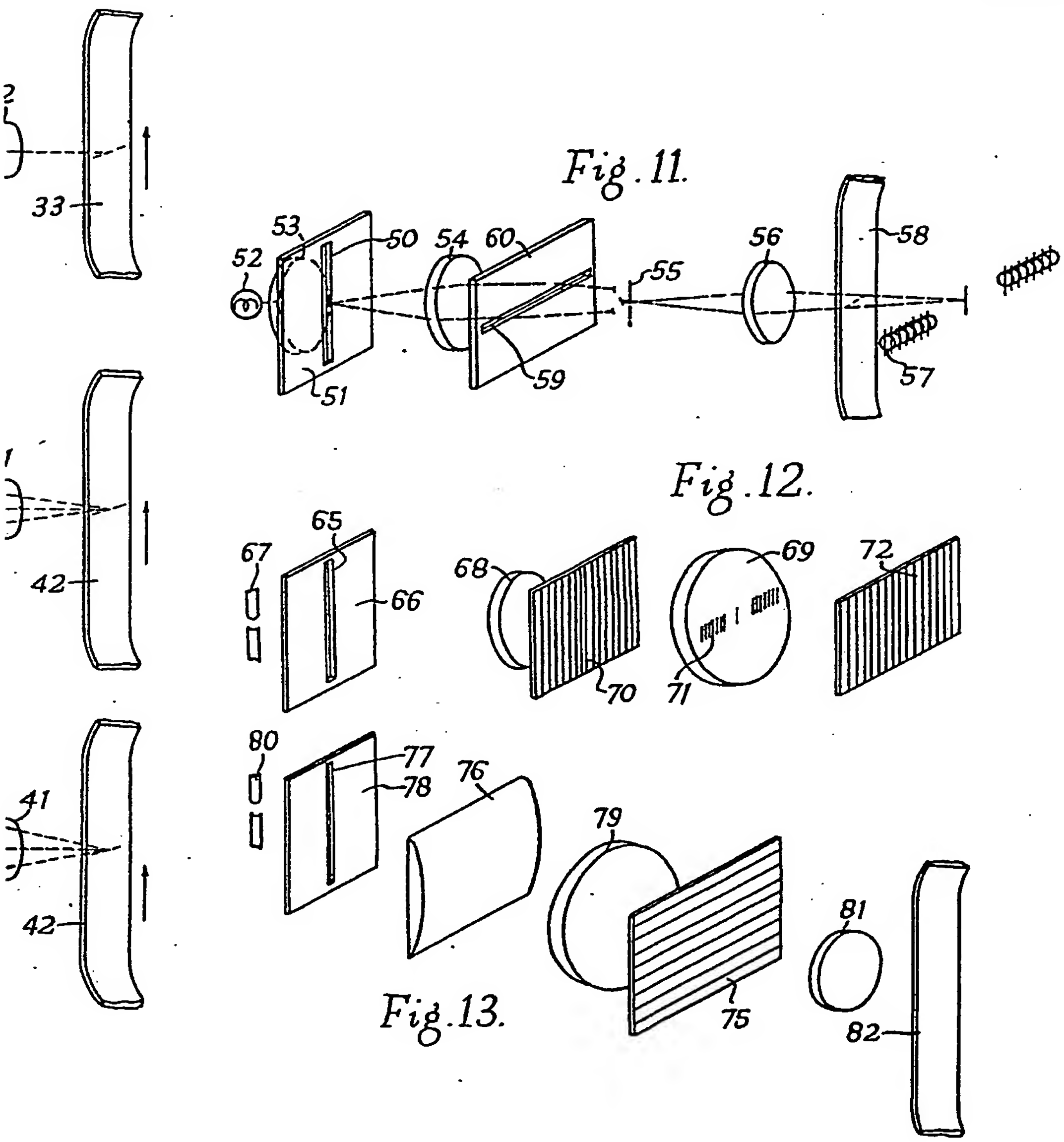
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 2 & 3



1082407 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 2 & 3

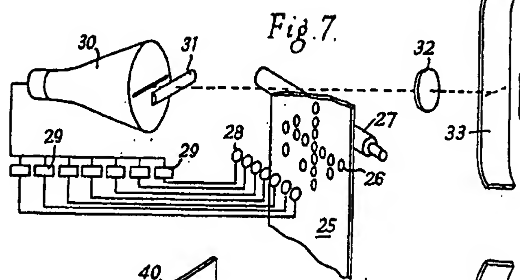


Fig. 7.

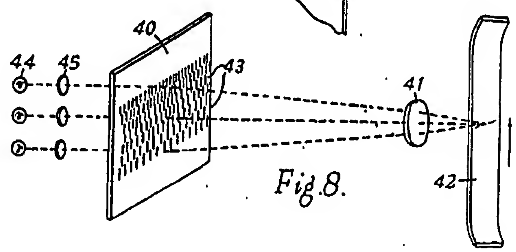


Fig. 8.

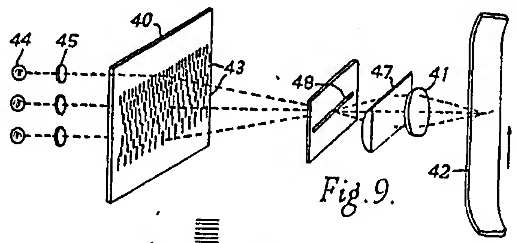


Fig. 9.

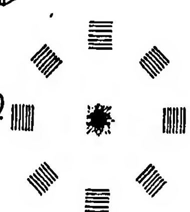


Fig. 10.

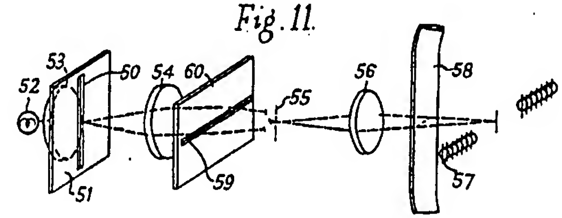


Fig. 11.

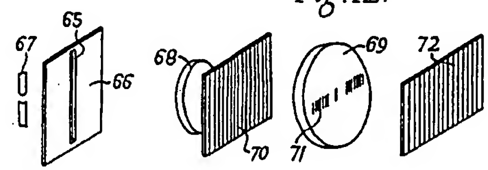


Fig. 12.

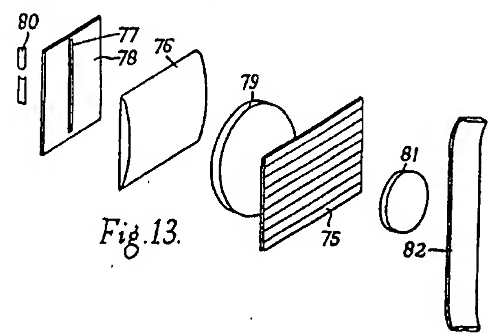


Fig. 13.